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ATMOSPHERIC COMPOSITION INSTRUMENTS

John M. Otis

Wentworth Institute of Technology
550 Huntington Avenue
Boston, Massachusetts 02115

Final Report

(1 September 1973 - 30 September 1977)

Approved for public release; distribution unlimited.

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the services supplied in support of the mechanical instrumentation for the LKD Section of the Aeronomy Laboratory for the Air Force Geophysics Laboratory.

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WENTWORTH INSTITUTE OF TECHNOLOGY

Final Report

Contract No. F19628-74-C-0014

I. INTRODUCTION

Contract No. F19628-74-C-0014 was initiated on 1 September 1973 with the Air Force Geophysics Laboratory, Hanscom Air Force Base, Bedford, Massachusetts, for participation in one of the many and varied phases of the comprehensive Upper Atmosphere Research Program being conducted by the Air Force Systems Command of the United States Air Force. This contract was completed on 30 September 1977.

II. SCOPE

The fundamental objective of the Upper Atmosphere Research Program is the acquisition of knowledge of the physical and chemical properties and phenomena of the vitally important atmospheric region by means of investigation, experimentation and observations carried on through the medium of instrumentation installed in, and borne aloft by, probing rockets and other upper air vehicles.

As part of the basic objective, this contract -- which was carried on specifically with the Aeronomy Division of the Air Force Geophysics Laboratory, and, more particularly, with the Composition Branch, LKD, of that Division -- stipulated that Wentworth Institute of Technology supply the necessary personnel, facilities, services, and materials to participate in the performance of research and development of laboratory apparatus and instruments for use in aerospace vehicles

concerned with the study of atmospheric composition; and to provide design, fabrication, testing, analysis and field support.

Included therein were the services of conducting engineering liaison with the Air Force Geophysics Laboratory personnel for the purpose of establishing instrument design requirements; mechanical design and detail of components and assemblies; fabrication of items resulting from the coordinated design; testing at this facility and at Government locations as may be designated by the cognizant Laboratory, and the analysis of the results of the tests to determine needs for possible re-design and to make recommendations for further research stages.

III. DESCRIPTION OF WORK

The tasks or cycle of activities which were undertaken to complete the various projects were conducted under the guidance of the Composition Branch, LKD, and consisted of certain fundamentally related phases. These tasks, as well as their related or supporting activities, involved the design, construction, assembly, installation, and testing of the instrumentation or supporting items for use in field and laboratory experiments. For example, such primary facets as the nature, scope and purpose of the experiment to be conducted; the parameters to be measured; the type of equipment to be flown; the schedules for completion, testing, and delivery or shipment of the equipment involved; as well as the establishment of target dates and the monitoring of the necessarily close coordination between the various participating groups -- all emanated from the monitoring Branch.

Within the specified scope of this particular contract, and through close liaison and coordination with the Contract Monitor, services, materials, and facilities were provided for each task from the preliminary discussion stages, through the design, fabrication, assembly, installation, and testing phases, to participation in field operations at the various launch sites and Air Force facilities as designated by the Aeronomy Division.

This report will constitute a brief over-all summary, focused, in chronological order and in quasi-historical format, upon major tasks or activities indicative of the basic objectives and accomplishments of the contract. No attempt has been made to repeat material which had been included at the time of its generation and relevance, in reports, published papers, AFGL in-house research records, and bulletins. In like manner, no attempt has been made to list, in depth, the many tasks carried on in the Drafting Section and the Machine Shop as a part of the standard operating procedures associated with the development, construction, assembly, installation, testing, and the analysis of the results of tests. However, some items are enumerated, in passim, in order to illustrate the quantities of "hardware" which had been fabricated and assembled for use in the instruments. The same is applicable to the processes involved in the redesigning, reworking and modifying of many of the instruments' mechanical components, inasmuch as this function

too, is deemed an inherent feature of any undertaking entailing the development and assembly of prototype experimental instruments with the aim of improving their operational efficiency and data gathering capabilities.

The initial tasks in the first contractual quarter, extending from 1 September to 30 November 1973, were concerned with the design modification of nitrogen and helium pumped mass spectrometer experiments. In particular, the multiplier housing subassembly -- for both helium pump and nitrogen pump units -- was redesigned to facilitate the deletion of several welded joints in the housing's construction. Drawings were revised to reflect the design modifications, as were assembly and detail drawings prepared of the new improved design. Plans were made to construct four (4) helium units and two (2) nitrogen units. The fabricating phase for several of the unit's components was in process. The partial shipment of aluminum oxide ceramic parts, contracted to Ceramics Grinding Company, were received and delivered to the Aeronomy Laboratory.

Modifications were completed to the Ion Neutral Flight Instrument Switch design. An ion source assembly design was revised and a new drawing of it was prepared, incorporating the modifications; detail and sub-assembly drawings were also completed for this unit to reflect the design changes. Eight filament holders were fabricated and delivered to EG&G Corporation for the installation of the filament wire.

Plans to fabricate the base and housing for the mass spectrometer flight instrument had commenced while the remaining aluminum oxide parts ordered from the Ceramics Grinding Company continued to be fabricated.

Inasmuch as titanium and stainless steel can present some problems in machining, some time was devoted to experimenting with electric discharge machining techniques to determine the feasibility of their use on components where machining with small diameter cutters would be difficult. Satisfactory results were achieved in cutting slots in the filament holder, and ion source with both titanium and stainless steel by this method.

Tasks in the Machine Shop during this period were directed principally toward work on the ion source assembly. These tasks included the fabrication of the following components: 2 shield and rod supports; 8 ion source filament holders, six of stainless steel and two of titanium; 8 No. 1 ion source filament electrodes, six of titanium and two of stainless steel; 8 quadrupole rods, four per Dwg. No. LK72-175B-1 and four per Dwg. No. LK72-175B-2; 1 Quadrupole Housing, Dwg. No. SW-I-N LKD73-82C, and 3 Ion Source Ionization Boxes, SW-I-N LKD73-81C.

During the second quarter, which extended from 1 December to 28 February 1974, particular emphasis was directed towards tasks pertaining to revisions of an LKD design for a helium-pumped flight instrument. Upon the completion of these design

modifications, fabrication was initiated on two base plates, housings, and associated hardware. They were delivered to the Aeronomy Laboratory upon their completion with the exception of one base plate. This component was held up because of the delay on the part of a supplier to furnish the feed-throughs on the expected delivery date. Six multiplier housings were fabricated and delivered to the LKD Laboratory.

In addition, an electrode assembly -- a composite assembly consisting of four pieces joined together -- was redesigned into a single component part for economy and manufacturing simplicity. However, problems were encountered in the fabrication of the single part and required an additional design modification to make the transition process successful. Several redesigned parts were fabricated using a ball end mill tool for examination and design evaluation purposes. A layout and several design drawings were initiated for a nitric oxide experiment chamber.

The majority of the tasks undertaken in the Machine Shop for this quarter were related to the development of the electrode assembly, LKD73-83C-1 and LKD73-83C-2. Among the items completed were the following: 8 Support Rod Multipliers, LKD73-85A; 2 bakelite caps, modified; 3 Mounting Plate Collectors, LKD-72-99B; 3 End Plates, SW-I-N, LKD73-93B-1; 3 End Plates, SW-I-N, LKD73-93B-2; 3 Grid Rings, LKD72-117A-2,

(plus a turning fixture); 3 Upper Deck Plates, SW-I-N, LKD73-94C; 3 Middle Deck Plates, SW-I-N, LKD73-95C; 1 ionization box, LKD73-31C; 8 Multiplier Support Rods, LKD73-85A; 2 Quadrupole Apertures, LKD73-83A; 3 Mounting Plates, LKD73-84B; 2 Quadrupole Housings, LKD73-82C; 6 Plates, #3 side, LKD72-87A; 3 Grid Plates, LKD72-153A; 2 Filament Support No. 1 Ion Sources, LKD72-96B-2; 2 Aperture Covers, Retainer, LKD72-149B; 2 Aperture Covers, Ice Cap 73 Instrument, LKD72-148B (plus a turning plate); 2 Pump Brackets, LKD73-105B-1; 2 Pump Brackets, LKD73-105B-2; 4 Multiplier Support Rods, No. CRAZ-70-47B (plus a milling fixture); 2 Multiplier Support Rings, CRAZ-70-47B (plus a turning fixture); 8 masking plates, off-axis multiplier, bottom; 5 multiplier shield plates, Project NACS, and 1 Front Housing, Shock Tube Assembly, LKD73-69D, with the exception of the generation of the venturi opening.

During the third quarter, which extended from 1 March to 31 May 1974, attention was directed towards the preparation and build-up of a flight instrument. To fulfill this task within the deadlines, several aspects of the project were awarded to subcontractors with particular emphasis given to certain areas of expertise and quality. Ceramics Grinding Company was given two job orders to fabricate all ceramic components for the instrument. These items were completed and delivered to this institution. Likewise, a subcontract was

given to Barkley & Dexter Laboratories to fabricate the stainless steel components comprising the quadrupole support rods, and associated unit parts; which they completed for a fulfillment of another phase of the project. Thermo Electron Company took part in the fabrication and electron beam welding of the nitric oxide chamber for the instrument. They supplied the welding tubing connections while this institute furnished the stainless steel vacuum flanges. The completion dates for these tasks were estimated to be early June 1974.

A quantity of feed-throughs were purchased from Glass Instruments Company, comprising 42 pieces of No. CRUZ-67-06A, and 28 pieces of No. CRAZ-70-51B-1. In addition, ten (10) ion source cone assemblies were obtained from Astro Dynamics. Further, a quantity of 144 grid insulators, fabricated from Kel-F, were procured from Forest Products, Inc. A supply of cal-rod heaters, per Dwg. LKD71-84B, was ordered from General Electric Corporation.

In the latter part of the third quarter, Mr. M. McDonald, mechanical designer, took part in the integration of a vacuum system in the Aeronomy Laboratory at Air Force Geophysics Laboratory.

Machine Shop tasks completed during this period included the following: 1 Attached Shock Front Housing, LKD73-69D; 1 Ionization Box, Ion Source, SW-I-N, LKD73-81C; 1 Female Connector Mount, LKD72-62A; 5 Female Connector Mounts, LKD73-5A; 5 Gauge Flanges, CRAZ-69-52B; 4 Valve Stand-offs, LKD73-52B;

special tubes and 2 cross tees, modified; 4 Anode Spacer Rings (lower), CRUZ-67-29C; 6 Retainer Quad Housings, LKD72-132B; 5 shield plates, modified; 2 Potential Plane Plates, LKD73-2A; 5 Ion Pump Tube Extensions, LKD72-144A; 1 Support Plate, LKD74-5B, 1 Blow-off Cap Seal, CRUZ-67-047B; 1 Neutral Quad Plate Retainer, CRUZ-67-048B; 2 hex studs; 4 Grid Plates, LKD72-118A-5; 3 Grid Plates, LKD72-118A-6; one 7¼" stainless steel tube, modified; 10 Top Plates, LKD72-59B; 10 Bottom Plates, LKD72-60B; 1 fixture for top and bottom plates; 1 aperture plate; 1 stainless disc, fitted to copper gasket; 1 adapter ring, Nitrogen Instrument and 1 Adapter ring milling fixture, LKD71-105D; 2 Bake-out Mounts, LKD74-14C; 3 tee fittings, modified; 3 pump housings, modified; 1 stainless steel nose adapter and 10 grid plates, LKD73-3B-1, with 1 milling fixture; 3 Support Rods, LKD74-6B-1; 3 Support Rods, LKD74-6B-2; 2 support brackets; 10 Filament Holders, Ion Source, LKD73-7CB, and 5 Anode Ion Sources, CRUZ-67-31C.

During the last quarter of the first year of the period of performance, namely, from 1 June to 31 August 1974, activities were directed toward the revisions of mass spectrometer design drawings and in generating new drawings to accommodate adaptation processes to a positive ion instrument.

The scheduling of tasks to the Machine Shop for the fabrication of components for various instruments was coordinated. A search for specific tools and equipment to perform certain machining phases was also undertaken. Due to the heavy workload and tight schedule, certain of the overflow tasks were assigned

to various manufacturing vendors. Components requiring specialized manufacturing processes and current state of the art technology, such as the joining of glass feed-throughs to adaptors and base plates were given to an appropriate vendor who specialized in electron beam joining of small parts. Electron beam welding was chosen over heli-arc welding primarily because of its inherent low distortion and deep penetration qualities. This proved to be the superior method in achieving the best results for our application.

Trips were made to the Aeronomy Division at the Air Force Geophysics Laboratory for discussions on drawing revisions, design changes, and for new drawings. Several trips were also made to take part in the installation of some equipment for an environmental test chamber.

Tasks completed in the Machine Shop during this quarter included the following: 8 Anode Ion Sources, Neutral Quad., CRUZ-67-31C-2; 8 Assembly Blocks, LKD71-70A-2; 6 Adaptor Rings, Nitrogen Instrument, CRUZ-72-31C-2; 4 spacers; 3 Lead Tubes No. 2, LKD72-108A; 1 Quadrupole Housing, SW-I-N LKD73-82C; 1 Ion Box, Positive, LKD74-16C; 1 Top Grid Plate, LKD72-151A and 1 turning fixture; 8 Quadrupole Rods, LKD74-17B; 1 thread grooving fixture; 20 screws with groove recessed to root diameter; 40 Pump Brackets, LKD73-105B-1-2-3-4; 2 teflon gaskets; 2 modified Middle Decks, LKD73-95C-2; 8 Adaptors, LKD72-105A; 2 milling fixtures for Base Plate, LKD72-127D-1; 1 Base Plate, LKD72-127D; 4 Lead Tubes No. 1, LKD72-107A-1; 3 Electrical Feed Screw Mounts, LKD71-102A;

1 modified copper seal flange, and 2 Lead Tubes No. 3, LKD72-109A.

During the first quarter of the second contractual year, 1 September to 30 November 1974, particular emphasis was placed upon the generation of new designs for two portable tables and cryo-still support frame for the Air Sampling Project. The design, preparation of drawings, fabrication and the assembly of the portable table and cryo-still support frame were all completed. They were delivered to the air sampling facility for installation. Reference is made to the cryo-still support frame No. LKD74-22E which had been designed and fabricated. This stand, measuring 6 feet, 3 inches long, 1 ft., 5 inches wide, and 4 feet, 1 inch high, was constructed from 3" x 3" aluminum angle welded. It included two formica laminated shelves.

The mechanical assembly of the gas inlet for a satellite table leak system was completed. In the inspection of the satellite table leak system, a number of shielded-type feed-throughs were found to have an unacceptable leak rate and could not be utilized. Consequently, the feed-throughs were re-ordered under the condition that the manufacturer, Glass Instruments, Inc., certify in writing -- the feed-throughs comply to the leak rate requirements. Many miscellaneous design and drawing revisions were also completed during this period.

Shop tasks completed during this period included the following: 2 Lead Tubes No. 3, LKD72-109A; 1 Lead Tube No. 3 turning fixture; 1 Top Grid Plate, Icecap "73" Instrument, LKD72-151A with a turning fixture; 1 Upper Deck, titanium, SW-I-N LKD73-94C; 1 Upper Deck, stainless steel, SW-I-N LKD73-94C; 1 Collector,

LKD72-93A; 1 Angle Bracket for Leak System, LKD74-21D; 1 Filament Support No. 1, Ion Source, stainless steel, LKD72-96B; 1 Filament Support No. 1, Ion Source, titanium, LKD72-96B; 3 "U" bolts; 8 Assembly Blocks, LKD71-70A-1; 16 Assembly Blocks, LKD71-70A-2; 4 End Plates, LKD73-93B-1; 4 End Plates, LKD73-93B-2; 2 Shield Plates, LKD72-155A; 9 deck supports; 2 Multiplier Support Rings, CRAZ-70-48A; 8 Support Rod Multipliers, LKD73-85A; 1 Ionization Box, Ion Source; stainless steel, LKD73-81C; 1 Ionization Box, Ion Source, titanium, LKD72-81-C; 2 Electrode Assemblies No. 1, LKD73-83C-1; 2 Electrode Assemblies, LKD73-83C-2; 12 Grid Rings, LKD72-117A-1-2, and 2 Grid Ring turning fixtures, LKD72-117A-1-2.

Attention during the second quarter of the second year of performance, from 1 December 1974 to 28 February 1975, was placed upon the fabrication of components for the assembly of several helium mass spectrometers. A portable pumping station was designed and fabricated. The station was designed to accommodate existing vacuum equipment belonging to the Aeronomy Laboratory. A large jack was utilized to provide a means of adjustable support for the helium instrument, and a shipping container was constructed for its transportation to the cognizant Laboratory.

A portable field pumping station for the balloon borne air sampler was also designed. The complexity of the stand's structure warranted a considerable amount of welding. Both portable pumping units are intended to be employed in the field to support an experiment. Drawings for a multi-port manifold and

special cross fittings which were applied in conjunction with the portable field station were prepared, and parts were fabricated. A high vacuum gauge, cold cathode gauge, and a gauge tube, as well as various sizes of flange adapters were installed on both the portable pumping station and the field station. In addition, a 4" manual-operated high vacuum gate valve and a pump with an associated control unit were incorporated in the system.

Fabrication of an aluminum gondola structure and ballast hopper for the balloon sampler system had commenced. A delivery date of early April was quoted. Construction drawings were supplied by the LKD Laboratory.

Shop tasks during this quarter included the fabrication of the following: 6 Grid Rings, LKD72-117A-1; 6 Grid Rings, LKD72-117A-2; 2 Grid Ring turning fixtures; 4 Multiplier Support Rings, CRAZ-70-47B-1; 4 Multiplier Support Rings, CRAZ-70-47B-2; 1 each turning and milling fixture for the Support Rings, 3 complete sets of LKD72-169B magnetic keepers, including 3 rings (fabricated from 2 halves and welded) and 18 stainless steel clamps; 1 Middle Deck, LKD73-95C; 4 Lead Tubes, No. 3, LKD72-109A; 2 Lead Tubes, No. 1, LKD72-107A-1; 8 Grid Rings (positive ion) LKD74-19A; 1 Mounting Plate with hole layout; 1 Portable Field Station Stand, LKD75-103, and 1 Portable Pumping Stand, LKD75-105.

In the beginning of the third quarter of the second year, which extended from 1 March to 31 May 1975, several sketches of component parts for the mass spectrometer instrument were prepared while drawings of parts for the SW-I-N instrument, namely

the base plate and feed-through mounts, were revised. These revisions were the result of the decision to weld the feed-throughs on the vacuum side of the base plate rather than on the external section in preventing outgassing of the feed-through base plate interface. The SW-I-N Housing, LKD73-96D was re-designed; this entailed making the upper half of the housing separable, with an "O"-ring seal in the interface. All the drawings associated with the redesign of the housing were completed. Drawings for the Ion Housing Assembly and Blow-off Cap were also completed.

Detail sketches were prepared for the fabrication of a shipping crate for the portable field station (reference to which had been made in the second quarter of the second year), as well as for the construction of a fixture to support the cryo-still. A specialized shipping crate for the cryo-sampler was also designed and constructed.

In the Machine Shop, tasks were continued in connection with the construction of the balloon gondola and ballast hopper. These units were completed and delivered to the cognizant Laboratory in April, 1975. Additional tasks completed in the shop included the following: 1 Top Grid Plate, Ice Cap "73", LKD72-151A; 1 Exit Orifice Cap, Positive Ion, LKD74-18A; 3 Filament Holders, Ion Source, LKD73-79B; 1 Adaptor Flange, CRUZ-67-224C; 1 Adaptor Flange milling fixture; 3 Conflat flanges; 12 Quadrupole Rods, LKD75-4B, 1 & 2; 8 straps, per sketch; 4 Deck Supports, LKD72-112A; 1 Middle Deck, LKD73-95C; 1 Upper Deck, LKD73-94C; 8 Grid Rings, LKD72-117A-2; 2 Lead Tubes, LKD72-108A; 4 Blow-off Cap Seals, Neutral Quad., CRUZ-67-048B; 1 Sampling

entrance tube, per sketch; 13 stand-offs, per sketch; 13 spacers, per sketch; 1 frame attachment for portable field station; 1 Acme Thread Spindle, per sample; 1 Retainer Cover, LKD75-6C; 1 shipping crate for the portable field station; 5 slotted screws, per sketch; 8 gas sampler adaptors; 8 gas sampler end caps; 8 sampler cylinders, modified; 2 Alignment Pins, Ion Source, LKD71-90A1; 1 Insulator, LKD75-20C, and 1 Locating Plate, LKD75-6C. The fabrication of 1 Base Plate, LKD72-127D, and 1 Ion Source Housing, LKD75-7C, had commenced.

The last quarter of the second contractual year covered the period from 1 June to 31 August 1975. During this period, the Drafting Section was involved in the generation of detail design drawings for the application of glass ceramic insulators and Kel-F gaskets.

Manufacturing tasks during this period included the fabrication and assembly of a second ballast hopper for the air sampling gondola. Thermal Electron Corporation fabricated and delivered one Ion Neutral Housing. In addition, four (4) off-axis multiplier housings were built by Barkley and Dexter Company. Two of the units were different in that shielded feed-throughs were mounted in the assembly at right angles to the housing axis.

Other tasks completed in the Machine Shop during this period included the following: 1 Ion Source Housing, LKD75-7C; 1 Cover Plate, LKD75-18A; 11 Insulators (Corning Glass Ceramics), LKD75-16A; 2 Spring Holders, LKD75-17A; 1 Filament Shield,

LKD75-8A-1; 1 Disc, LKD75-8A; 10 Insulators, Kel-F, LKD75-16A; 1 Insulator, LKD75-6C; 4 Teflon washers were fabricated and 10 screws were slotted; 3 Filament Shields, LKD75-8A-1; 2 Electrical Feed-Through Mounts, LKD71-102A; 2 Adaptors, LKD72-105A; 4 Mounts, Hermetic Seal, LKD71-103A; 1 Base Plate, Switch Ion, LKD73-97D; 5 plug seals and 5 Teflon inserts; 7 Ion Source Filament Shield Discs, LKD75-8A-2; 4 Filament Holders, Ion Source, LKD73-79B; 3 levelling plates (per sketch); 3 vacuum line adaptors (per sketch), and 14 Grid Plates, LKD72-136A.

In the early part of the first quarter of the third year, which extended from 1 September to 30 November 1975, considerable time was devoted to the design layout, detailing and fabrication of two sampling transport spheres. This produced sixteen hemispheres, generated by a spinning process. The hemispheres were stress relieved to neutralize the stresses induced in the generating process. Following the stress relieving process, the inside surfaces of the hemispheres were buffed and polished to improve the surface finish.

A remote control operated valve unit was fabricated and assembled; after delivery to the Aeronomy Branch, tests were conducted, with several design modifications implemented. The particular drawings involved were revised to comply with the modifications.

A motor operated by-pass unit was also constructed for use in conjunction with the air Tri-Sampling Unit. The layout and details for a liquid helium-cooled dewar had also commenced.

Tasks completed in the Machine Shop during this period included the following: 1 Positive Ion Box, LKD74-16C; 1 Top Grid Plate, LKD72-151A; 1 turning fixture for Top Grid Plate; 5 Quadrupole Rods, LKD74-17B-1; 5 Quadrupole Rods, LKD74-17B-2; 15 sampler tube adaptors, per sketch; 15 sampler tube end caps, per sketch; 5 Deck Supports, LKD72-112A-2; 1 Link, Valve Drive Assembly Blocks, LKD75-33B; 1 Housing, Valve Drive Assembly, LKD75-25D; 1 extension, 2 1/16 x 1 1/8 O.D. x 7/8 I.D.; Valve Drive Assembly Pin, LKD75-28A; 1 Valve Drive Assembly Thrust Washer, LKD75-29B; 1 Valve Drive Assembly Screw, LDK75-26B; 1 Valve Drive Assembly Male Screw, LKD75-27B; 1 teflon cap; 6 brackets, by-pass assembly; 3 Pins, Valve Drive Assembly, LKD75-28A; 4 orifice plate mounts, by-pass assembly; 1 special socket wrench, Valve Drive Assembly; 1 orifice plate; 1 blower adaptor; 1 main housing, and 2 Electrical Feed-Through Mounts, LKD71-102A. Modifications were also made to a Varian valve; 15 sampler tubes; a Globe Motor shaft; a base plate; a housing, and a female adaptor.

At the close of this period, work was in process on a sphere heater clamp, consisting of two halves, 15½" in diameter, with two pieces to each half. A special face plate was fabricated for turning purposes.

In the beginning of the second quarter of the third year of performance (from 1 December 1975 to 29 February 1976); considerable time was spent in up-dating assembly and detail design drawings for the following units: Blower By-pass Assembly, Remote Control Valve Drive Assembly, Transport Sphere Assembly, Brace Assembly, and heating clamps for the spheres. A detail drawing was

prepared for the grid plate.

The Transport spheres were delivered to the Lab in December. Difficulties encountered in the gold plating of the spheres and cold finger caused a slight delay in the original delivery plan.

Tasks completed in the Machine Shop during this period included the following: 6 brackets for the by-pass assembly; 3 Pins for the Valve Drive Assembly, LKD75-28A; 4 orifice plate mounts; 1 orifice plate for by-pass assembly; 1 blower adaptor for by-pass assembly; 2 Electrical Feed-through Mounts, LKD71-102A; 1 base assembly; 1 Female Nut for Valve Driver Assembly, LKD75-26B; 1 Male Screw for Valve Driver Assembly, LKD75-27B; 2 adaptor plates; 2 adaptor plugs for 1000 cc. sampler tubes; 2 butt weld adaptors; 2 four-inch neck adaptors for 500 cc. sampler tubes; 2 adaptor plugs for 500 cc. sampler tubes; 2 Exit Orifice Caps (positive ion), LKD74-18A; 8 Quadrupole Rods (positive ion), LKD74-17B, 1 & 2; 2 Ionization Boxes, LKD74-16C; 2 End Plates for Housings, LKD73-96D; 1 Top Grid Plate, Ice Cap 73, LKD72-151A; 2 Sphere Heater Clamps (inner), LKD75-38D, and 2 Sphere Heater Clamps (outer), LKD75-39D. The latter parts were used to form two halves, each with an inner and outer section. Each section required grooves to accommodate heating elements which were fitted between the inner and outer sections on both halves.

Modifications were made to 1 Valve Driver Assembly Housing, LKD75-25A; 1 female adaptor, Valve Driver Assembly; 1 Globe

Motor, LKD75-31C; 2 Conflat flanges; 1 double-sided Conflat flange, two 1000 cc. sampler tubes, and two 500 cc. sampler tubes. Three magnet bands, and 2 Housings, LKD73-96D, were refurbished. These latter units had been flown and were damaged.

During the third quarter of the third year, 1 March to 31 May 1976, activity was centered around the design modifications to the transport sphere assemblies. The cold finger was redesigned to provide an increased internal volume by using an internal sphere. The inner sphere's volume was calculated and found to be 11.0 liters (1100 cc.), changing the contained sample volume of the transport sphere from 23.5 liters to 12.5 liters. The modifications resulted in the preparation of additional mechanical drawings, which included the hose connector, split hose connectors, and special Marmon clamps. Two transport spheres were constructed for a pending balloon flight.

Tasks completed in the Machine Shop during this period included the following: 2 Aperture Covers, LKD72-143B; 1 Housing, Valve Driver Assembly, LKD75-96D; 2 Sets of Housing Covers, LKD76-92C; 11 sampler tube end caps; 10 reducing adaptors 1" long for sampler tubes; 1 reducing adaptor 4" long for sampler tube; 2 reducers, 1" O.D. to ½" O.D. x 4" long; 2 reducers 3/4" O.D. to ½" O.D. x 4" long; 4 sets Marmon Clamps, LKD76-19D; 1 flaring tool; 8 nuts for Marmon Clamps, LKD76-21B; 8 Retainer Bolts for Marmon Clamps, LKD76-22B; 1 end cap for 1000 cc. sampler tube, and one 1 1/8" reducing adaptor for 1000 cc. sampler tube. Modifications were made to one 300 cc. sampler tube; 7 500 cc. sampler tubes tubes; three 150 cc. sampler tubes; 11 Bendway

metal duct connectors; 1 Conflat flange for the ion gauge, and one 1000 cc. sampler tube. One liquid helium 30" Dip Stick, LKD75-43E was redesigned. The existing unit was disassembled, and new parts fabricated, including 1 extension tube, 1 sleeve, 1 washer, 1 3/8" O.D. tube 27 ½" long, and 1 ¼" O.D. tube, 27 ¼" long. Two prototype models of a Wind Indicator Zero Velocity Shield Assembly were also fabricated.

The last quarter of the third contractual year covered the period from 1 June - 31 August 1976. Work was primarily directed toward the redesign of the High Altitude Mass Spectrometer and its multiplier housing. In addition, plans and drawings were generated for a gas chromatograph gas injection panel and electronics module including brackets for mounting it to a laboratory table. Drawings of several small instrument parts were also prepared.

Tasks completed in the Machine Shop during this quarter included the following: 1 Stand for the Liquid Helium Cooling System, LKD76-35C; 12 Quadrupole Rods, MS-V, LKD76-62B; 2 pump supports; 1 Coil Bracket, MS-V, LKD76-91B; 1 SS tube, 3" diam. x 30-3/32 long, per sketch; 1 instrument-mounting panel (gas input) machined and engraved; 1 aluminum plate, 17 3/4 x 8 ½ x ¼, per sketch; 2 braces for gas input instrument panel, per sketch; 1 mounting angle, per sketch; 1 mounting bracket, per sketch; 8 spacers, 2 ½" diameter, per sketch; 1 console support frame, comprising one each hanger plate, hanger bar, spacer plate, rear support angle, and two end support angles; 1 mounting bracket, per sketch; 1 SS sleeve; 2 special brass nuts, per sketch; 2 rods, 5/16 O.D., 10" long, threaded 2 ends, per sketch; 1 SS elbow, per sketch; 1 gate valve actuator; 2 mounts for gate

valve actuator; 30 Kovar sleeves, glass-to-metal feed-through; 2 nylon spacers for gate valve actuator, per sketch; 1 handle for gate valve actuator, per sketch; 3 sampler tubes, 75 cc.; 3 sampler tube adaptors, per sketch; 3 sampler tube end caps, per sketch; 1 console support frame; 1 rack for console; 1 Multiplier Housing Flange, LKD76-70B; in addition to a modification of a Conflat Flange, a 2 3/4" Conflat Flange, and an aluminum box with cover.

During this period, work was started on a Liquid Helium Dewar Assembly, utilizing a split cover, an inner can, and a clamp, and without requiring liquid nitrogen shielding.

During the earlier part of the first quarter of the fourth year, which extended from 1 September to 30 November 1976, work was continued on the preparation of preliminary drawings in redesigning the High Altitude Mass Spectrometer. The redesign was necessitated due to space and weight limitations on board the flight vehicle. After approval of the preliminary design drawings, all necessary drawings, namely, detail, layout, and assembly, were initiated. The drawings were completed with minor revisions and were then released to the Machine Shop for fabrication of 3 units.

Tasks completed in the Machine Shop during this period included the following: 2 gas manifold tubes, per sketch; 3 gas manifold spacers, per sketch; 1 stainless steel adaptor, .125 to .250 diameter per sketch; 1 multiplier housing flange, per sketch; 1 flange adaptor for gas chromatograph, per sketch; 1 tube support for gas chromatograph, per sketch; 1 Union adaptor for

gas chromatograph, per sketch; 1 Union adaptor broach; 1 Hi-Q mounting block, per sketch; 3 flange support mounting blocks, per sketch; 3 pairs of flange support clamps, per sketch; 1 angle mounting bracket, gas separator unit; 1 bellows valve insert, per sketch; 6 Coil Brackets, LKD76-127B; 3 Coil Cores, LKD76-126B; 3 Pull-off Caps, LKD76-132B; 3 Aperture Covers, LKD76-131B; 14 Quadrupole Rods, LKD76-128B; 6 Stainless Steel Tubes, bent to form, LKD76-117B; 3 R. F. Coil Box Covers, LKD76-140B; 3 Sensor Brackets, LKD76-141B; 4 M. S. Sensor valve supports, per sketch; 4 M. S. Sensor Grid Plates, LKD76-142B; 4 M. S. Sensor Grid Plates, (Rod Housing) LKD76-122B, and 1 Rod Housing, LKD76-111D.

Modifications were made to the following: 1 tee fitting for gas manifold; 1 el fitting for gas manifold; 1 angle mounting bracket; 3 tube adaptors, ¼" to 3/8"; 5 M. S. Sensor Tubes, LKD76-117B; 6 tube adaptors, ¼" to 3/8"; 2 Orifice Plates, LKD76-123C; 6 elbows, 90°, and 2 rod housings.

In the early part of the second quarter of the fourth year, which extended from 1 December 1976 to 28 February 1977, all appropriate design layout and detail drawings were reviewed and revised to reflect the reconfiguration of the "WBSS-MS-Sensor".

Activity was started for both 7.5 liter and 15 liter air sampling transfer spheres. The spheres are basically constructed from two commercial stainless steel bowls welded together. The bowls were annealed to reduce the hardness of the material, thereby improving its machining and welding characteristics. However, during the vacuum testing of the spheres, the

bowls collapsed. In evaluating the cause of failure, it was determined that the structure's yield strength was reduced below a critical point in the annealing and electro-polishing process, which affected the thickness of the bowls. The cause of failure was attributed to this. Suitable stiffening members were incorporated in the spheres.

Tasks completed in the Machine Shop during this period included the following: 1 Rod Housing, LKD76-111D; 3 Fit Cover Plates for Electric Boxes, LKD76-134C; 6 plates for Cannon connectors, per sketch; 1 Feed-through Adaptor for Multiplier Housing, LKD76-113D; 3 Coaxial feed-through connectors, per sketch; 1 Orifice Plate (front), LKD76-123C; 3 Box Covers, M. S. Sensor, LKD76-136B; 14 Insulators, Rod HSG Orifice Plate, LKD76-124A; 14 Insulators, LKD76-121A; 3 locating dowels for insulators and grid plate, sketch; 6 grid spacers, M. S. Sensor, sketch; 2 Connector Plates for Electronics Box, LKD76-146A; 2 Side Mounting Plates for Electronics Box, LKD76-147A; 1 Conflat to hemisphere adaptor tube, sketch; 2 Connector Retaining Plates, CRAZ-69-15B; 2 flange plates, tube to hemisphere; 1 blower mount fixture, sketch; 2 Blower Mounts, LKD76-8B; 4 Orifice Plates, LKD76-9B; 12 Orifice Plate Mounts, LKD76-10A; 2 Tube Housings, LKD77-1C; 2 Tube Housing Flanges; 1 machined remote control driver to fit housing; 2 Brackets, By-pass Assembly, LKD77-6B; 2 Bendway connectors, sketch; 4 Male Screws (valve driver assembly), LKD75-27B; 4 Female Adaptors, LKD76-26B; 1 teflon spacer; 4 Quadrupole Rods, LKD76-128B-1 and -2; 1 set of stiffeners for 15-liter sphere; 4 adaptor tubes for hemispheres; 10 Quadrupole

Rods, LKD76-62B-1, and -2; 2 15-liter spheres, and 1 sampler tube end cap.

Modifications were made to 3 Base Plates for Electronics Boxes, LKD76-119D; 3 middle sections for Electronics Box Covers; 3 Electronics Boxes, LKD76-134C; 1 eleven-inch sphere; 2 Electronics Box Covers, LKD76-136B; 2 brackets for the M. S. Sensor; Conflat flange for the sampling sphere, as per sketch; 1 base plate, LKD76-145D; 1 multiplier housing cover; 1 front plate housing; 6 Swageloc connectors for blower assembly; 6 Swageloc elbows; 6 Conflat flanges; 1 pair driver screws; 2 Brackets for By-pass Assembly, LKD77-6B; 2 Connector Retaining Quad Plates, LKD77-4B, and 1 sampler tube, 300 cc.

During the third quarter of the fourth contractual year, from 1 March to 31 May 1977, design layout and detail drawings were completed for the DMSP experimental unit and in addition, several special layout and detail drawings were generated for the location and support of an appendage pump and valve. Revisions were made to the quadrupole housing and base plate in order to accommodate the pump and valve. A vibration fixture was also designed to hold the "WBSS-MS-Sensor".

A laboratory unit was designed and detailed drawings prepared for the ion cluster experimental work. A design layout of a flight ion cluster instrument was in process.

Tasks completed in the Machine Shop during this period included the following: 1 three-inch extension adaptor for the

75 cc. sampler; 2 welding fixtures for aluminum electronics cans; 4 nylon Coil Brackets, LKD76-91B; 6 Legs, LKD76-87B; 8 additional holes in Main Plate, LKD76-106D; 2 discs, 2.125 O.D. x .453 I.D., per sketch; 1 Ion Pump Bracket, LKD77-28B; 2 sets KEL-F Tubes for R. F. Elbow; 1 vibrational test fixture for "WBSS-MS-Sensor", LKD77-30D; 16 screws slotted along length and cut to length, per sketch; 2 sets of Marmon Clamps assembled, LKD77-26C; 1 Conflat flange to mate with 1" pipe; 8 angle clips, per sketch; 1 Manifold (pump and valve), LKD77-27B; 2 Ion Pump Brackets, LKD77-28B; 2 Z-bar clips for Bellows Valve, LKD-29B; 1 support for ion pump; 1 Spacer Ring (Multiplier Housing), LKD77-36C; 1 Flange (Multiplier Housing), LKD77-35B; 10 grids, .316 O.D. x .200 I.D. DMSP; 4 Multiplier Support Screws, LKD72-134B, and 4 Front Grid Plates, LKD76-56B.

Modifications were made to 4 Bottom Plates, MS-V; 2 cast aluminum junction boxes, per sketch; 1 Base Plate, LKD76-106D; 1 flange; 2 Swageloc fittings; 4 R. F. tubes, with changed radius; 1 Alcatel Pump Adaptor, LKD76-138B; 1 Marmon clamp with cables being added, and 1 Grid Housing, LKD76-106B.

Work was continued on an Upper Half for the Multiplier Housing, LKD77-32B, and a Lower Half, LKD77-33C.

The last quarter of the fourth contractual year covered the period from 1 June to 31 August 1977.

Design layouts and detail drawings for the ion cluster unit which was started in the previous quarter, continued to be

generated. The drawings completed include the following: Rod Housing support, LKD77-43D; Upper Rod Housing, LKD77-44C; three (3) Rod spacers, LKD77-40C; 42C; 41B and 45B; Quadrupole Rods, LKD77-47B and 48B; Base Plate, LKD77-39D; Lower Cone Assembly, LKD-53D; Cone section, LKD77-54D; and Lead Shield Tube, LKD77-58D.

A set of drawings for a Wind Indicator Instrument was developed from preliminary sketches received from AFGL. The set, containing ten (10) detail drawings and one (1) layout assembly, was delivered to the LKD laboratory.

The transport sphere detail-assembly drawing was revised incorporating design modifications to strengthen the mounting points and wall.

In a recent launching of a balloon gondola payload, the shock imposed on the payload's instrumented section from impact in the recovery phase caused severe damage to the Air Tri-Sampler instrument. As a result, a device was designed for application in future missions to cushion the instrument from the impact of a parachute landing. The cushioning device was designed to distribute the load of impact uniformly over a wide surface area and thus provide a greater bearing support for the instrument. The device incorporates a non-contaminating, resilient foam material sandwiched between two (2) aluminum plates to provide energy absorption at impact. An assembly and several detail drawings were prepared to delineate the design and specifications of the composite parts.

Tasks completed in the Machine Shop during this period included the following: re-machined the sealing knife edge of a

remote control valve, 4 Legs, LKD76-77B; 2 neoprene washers; 2 KEL-F insulators, per sketch; 2 KEL-F Valve Tube Extensions, LKD75-35B; 2 Squib Guides, LKD77-37D; 1 Multiplier Housing (upper half), LKD77-32B; 1 Multiplier Housing (lower half), LKD77-33C; 1 (flange), Multiplier Housing, LKD77-35B; 2 extension tubes for 7.5 liter spheres; 2 stainless steel plugs (15/16") for 15 liter spheres; 1 Squib Support, lower, LKD77-51B; 5 stiffeners, 5 1/8" O.D. for spheres; 6 tubes, 3/4" O.D. x 8" long, for welding to the flanges of the air by-pass balloon unit; 1 Conflat flange with 3/4" center hold, and 1 Conflat flange with ½" center hold.

Modifications were made to four (4) TRW Globe Gear Motors for the remote control valve driver assembly. The motor shafts were cut to length and squared, as per LKD75-31C; 10 brass screws, necked down to root thread diameter; mounted 2 Cryolab pump out valves on Conflat flanges; 2 Conflat flanges for 7.5 liter sphere; Conflat flanges added to 2 gold seal valves; 1 safety blow-off unit, re-machined knife edge; 6 flanges -- bored out tubing and made it to fit new tubing for the air by-pass unit; leaky vacuum bellows assembly repaired; 3 pair drive screws (remote valve driver), refurbished threads.

Work was done on four (4) parts in a liquid helium dewar assembly. A lathe fixture was made for turning the bottom plates.

A used 15 liter capacity sphere was opened to observe its inside condition and to remove damaged support brackets.

Both Tri-Sampler impact support devices have been fabricated, assembled and delivered to the LKD laboratory. Three of the five transport spheres required have also been completed and delivered. Work is being continued on the remaining two spheres.

During the final period extending from 1 September 1977 to 30 September 1977, development work was initiated on the C.I.M.S. instrument. Drawings were generated for this task and consisted of: Grid Plate, LKD77-60B; Grid Plate Insulator No. 2, LKD77-62B; Radial Support, LKD77-65B; Kel-F Insulator, LKD77-66B; Front Housing Attach Shock, LKD77-67D; and Ion Cluster Outline, LKD77-69D. In addition, drawings of the Filament Holder, LKD77-63B; Mounting Plate, LKD77-64B; and Leak Fixture Layout, LKD77-68D were prepared for the laboratory unit.

Tasks completed in the Machine Shop during this period included the following: 1 Tri-Sampler Shock Mount, 1 Conflat flange for the 15 liter sphere, 3 reducing couplings, ½" x ¼" x 3½" long; 6 links for the valve driver assembly, and 3 bottom plates for the Liquid Helium Dewar, LKD76-29D

IV. CONCLUSION

The foregoing section of this report represents a brief over-all summary of major activities, basic aims, and accomplishments of the Contract.

As has been noted earlier, no attempt has been made to cite in detail the many small supporting tasks undertaken in both drafting and fabrication phases of work. It is recognized that the finished instrumentation is a summation of the on-going

development process, incorporating many small modifications which could not possibly be mentioned in a report of this nature.

The Design and Drafting section under the responsibility of Mr. Martin McDonald and the Machine Shop under Mr. Otto Molter, were involved in a definite pattern of activities constituting a chronological cycle of preparation for field experiments with attention being given to both flight instrumentation and supporting Laboratory equipment. Reference is made to the fact that throughout the period of contract performance, the Drafting Department and Machine Shop were continuously engaged in design, drafting, modification, fabrication, assembly, reworking and installation of the many mechanical components required by the contracting laboratory to complete their mission.